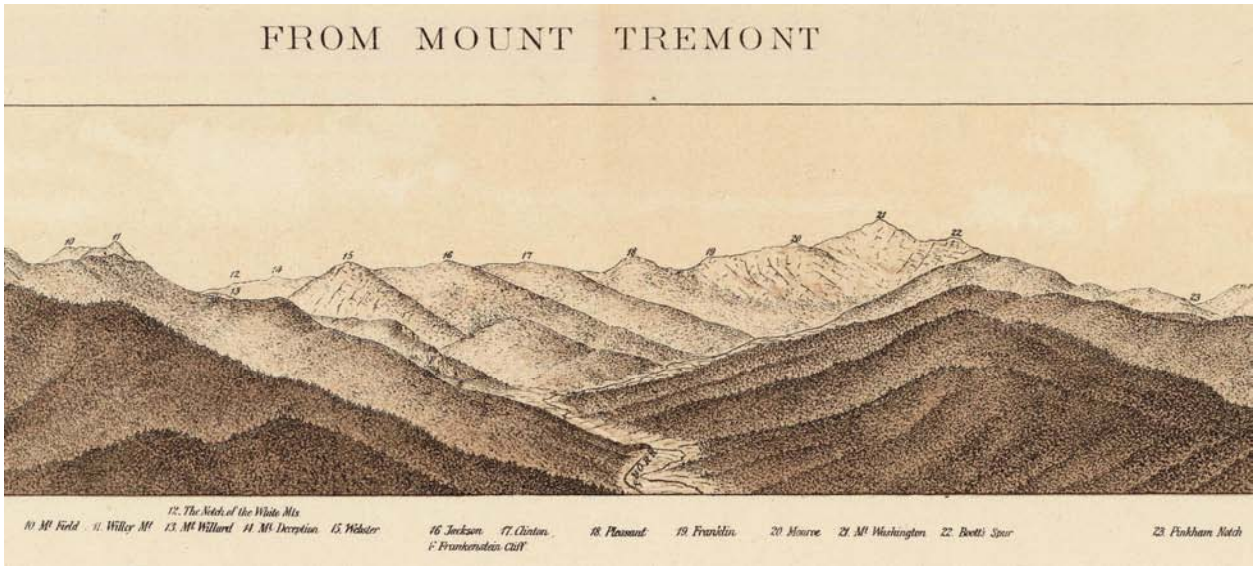
Field Trip Overview



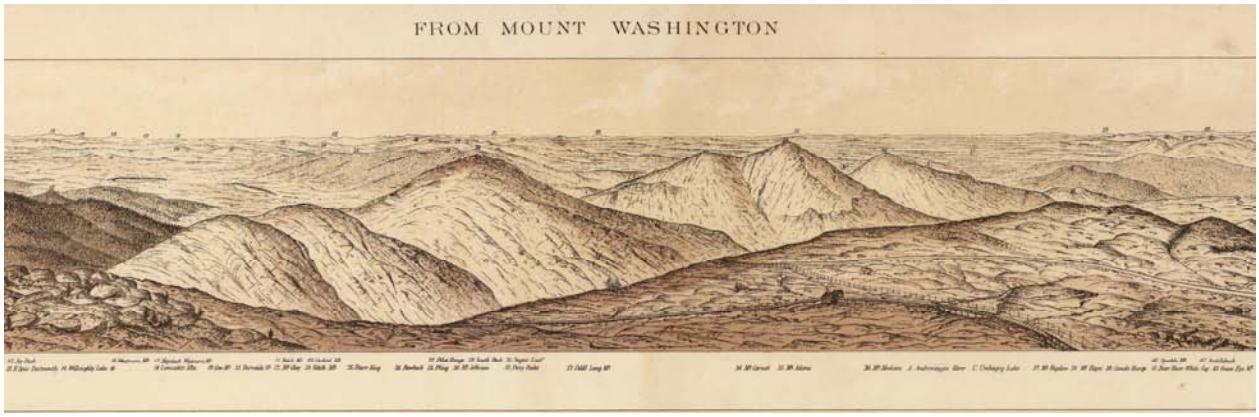
By Frederick Chormann

New Hampshire's identity as the "Granite State" dates back to the early nineteenth century, even before the First Geological Survey was authorized by the state legislature in 1839. Although the nickname is well-deserved given the widespread occurrence of granite and early importance of granite quarries as local, then commercial, sources of building stone, it fails to convey the true complexity of the geology that is found here. The rocks of New Hampshire record over 625 million years of earth history. Interpretations of that history, at first by a generation of gentlemen scientists and natural philosophers, reflected the prevailing and later discounted geologic paradigms of their times. Their skilled and careful observations, however, laid the foundation for those who followed them, mapping and re-interpreting in light of a growing and evolving understanding of planet earth. In New Hampshire, such luminaries as Marland P. Billings (Harvard University) and John B. Lyons (Dartmouth College), and their students, led the way into the modern era. General acceptance of the concepts of plate tectonics in the 1970's and development of accurate radiometric age dating techniques provided the foundation for the synthesis of knowledge that is represented by the most recent statewide bedrock geologic map (Lyons et al. 1997). Within the past 20 years, Dykstra Eusden and a host of geology students at Bates College have added significantly to our understanding of the bedrock geology of the Presidential Range of the White Mountains (Eusden, 2010).

At the conclusion of three year's field work that focused on completing a series of transects, several oriented southeast to northwest and perpendicular to the predominant structural trend, the first State Geologist of New Hampshire (1839-1842), Charles T. Jackson, mistakenly reported that granite constitutes the central axis of the White Mountains. The highest peaks in the Presidential Range are actually underlain by metasedimentary rocks of the Littleton Formation. In Jackson's defense, the relatively primitive state of roads and the breadth of unsettled regions beyond a small number of population centers made travel and mapping extremely difficult. The White Mountain region at the time was wilderness, inhabited by a few intrepid pioneers, offering

limited accommodations for travelers. Three decades later, state geologist Charles H. Hitchcock recalled his experiences with the Second Geological Survey that was completed in 1875:

"*The progress of the New Hampshire survey was much retarded by the presence of a dense forest covering an area of 2000 square miles in the northern portion of the state, and by the difficulties of transportation. All this mountainous forest had to be traversed on foot mostly without paths or guides. From the summit of Mount Washington a sea of mountains is visible. Every one of them was visited by some member of the survey, observations made and specimens preserved for study. At the present time [1896] railroads thread three-fourths of this forest country, and by excavations and the removal of the forests, facilities for exploration have been greatly increased. Had the survey of this region commenced fifteen years later, the information acquired could have been gathered in a fourth part of the time actually taken*." (C.H. Hitchcock, The Geology of New Hampshire, The Journal of Geology, Vol. 4, No. 1, Jan. – Feb. 1896, pp. 44 - 62).



From this perspective, the intersections between "highways" and "geology" are quite literally groundbreaking. No doubt Jackson and Hitchcock would have marveled at the field trip itinerary for the 64th Annual Highway Geology Symposium. The 120-mile loop not only traverses spectacular mountain scenery and sites of important historical events, but the Kancamagus Highway [NH Route 112], Franconia Parkway [I-93], and the 10th New Hampshire Turnpike [US Route 302] that comprise much of the route are themselves part of this history.

In the early twentieth century, state tourism officials boasted of the White Mountains region of New Hampshire as the "Switzerland of America", exploiting another nickname for the state that was popularized in Hayward's New England Gazetteer of 1839. While the comparison may be an exaggeration, at least one Swiss connection is worthy of note. Stop 4 introduces the glacial geologic history of the White Mountains and the contribution of the Swiss geologist Louis Agassiz who visited the Bethlehem area in 1847 and recognized some of the same features he had come to know in his beloved Alps. As you will learn, once the glacial origin of "drift" displaced the dilvuialist theories of the day, debates began in earnest over the detailed histories of continental versus alpine glaciation in the Whites. The matter is still not entirely settled, although recent 1:24,000-scale surficial geologic mapping under the auspices of the New Hampshire Geological Survey and the cooperative U.S. Geological Survey STATEMAP program, aided by acquisition of the first LiDAR terrain data within the region, is shedding new light on the subject.

The historical intersection between "highway" and "geology" is apparent once again in the generation of surficial mapping that was sponsored by the NH Highway Department (now Department of Transportation) in the 1930's. The expressed purpose of this project, under the leadership of James W. Goldthwait, the third NH State Geologist, was to locate the materials that were needed to expand the road network and stimulate tourism and economic growth. Subsequent mapping continued this focus on sand and gravel as an economic commodity, but beginning in the 1970's another focus was added, availability of groundwater resources. Cooperative projects with the U.S. Geological Survey produced a statewide series of stratified-drift aquifer maps that progressed from 1:125,000 to 1:24,000 scale before the final report in the latter series was published in 1997. These maps are still being widely used today as the basis for local groundwater protection.

New Hampshire History

By Frederick Chormann

New Hampshire can only claim 18 miles of Atlantic coastline as its own, the least of any coastal state in the United States, but that limited stretch of real estate has played a disproportionate role in its history. Explorers early in the 17th century recognized the potential of the deep-water harbor at the entrance of the Piscataqua River, leading into the tidal waters of the Great Bay and its major tributaries. English fisherman gained the first foothold, setting up temporary outposts from which to exploit the bounty of the rich coastal waters. The Isles of Shoals, a cluster of islands 10 miles offshore from the Piscataqua harbor (now divided between New Hampshire and neighboring Maine), supported active fishing communities.

The first organized attempt to create English settlements on the mainland came after Captain John Mason and his partner Sir Ferdinando Gorges (who eventually settled Maine) received land grants in 1622 from the Council of New England under the authority of the Crown. In 1623, David Thompson established the first settlement in what later would become New Hampshire at Ordiorne Point several miles south of the Piscataqua River in the present-day town of Rye. His Pannaway Plantation only lasted four years but several of its original inhabitants, brothers Edward and William Hilton, moved seven miles upriver to form their own settlement (now the City of Dover).

Captain Mason invested heavily in the company that he formed to establish and sustain settlements within his lands, a province which he named "New Hampshire" after the English county of Hampshire where his family seat was located. In 1630, the settlement of Portsmouth (originally known as Strawbery Banke) was founded on the west bank of the Piscataqua River harbor. This strategic location insured its continued growth and eventual prosperity as a center of maritime trade and shipbuilding. Mason died suddenly in 1635 at the age of 49 without ever setting foot in his province or seeing his investments become profitable.

The fur trade with the native inhabitants never became the profitable venture that was imagined by the early settlers. Relations with the indigenous tribes, the Pennacook and Abenaki (meaning "people of the dawnlands"), were peaceful at first, but hostility grew as more and more settlers occupied ancestral Indian lands and European diseases decimated their villages. Many of the new settlers came north from the Massachusetts Bay Colony, perhaps to escape the strictures of Puritan society in the largely ungoverned province of New Hampshire. Almost certainly they were lured by the plentiful land, timber, and fish and the economic opportunities that this natural wealth represented. The Puritan authorities in the Bay Colony coveted the same resources and alliances formed with some of the leading investors in the Piscataqua region to merge the two colonies.

After Mason's death, questionable claims arose regarding titles to the early settlements, compounded by a gross misconception of the true course of the Merrimack River that was specified as the southern boundary of his grant. Despite the efforts of Mason's heirs, the four plantations then existing in New Hampshire fell under the political control of Massachusetts until 1679. At that time, the Crown, already suspicious of the Bay Colony's expansionist aspirations and weary of the squabbling over governance, declared that New Hampshire constituted a separate colony and established a royal governor, an appointed council, and an elected assembly to govern it. The assembly was the precursor to the New Hampshire General Court that, with its 424 members, is the largest state legislature in the United States and one of the largest elected bodies in the world today.

Subsequent successors to the Crown allowed the balance of political power to shift back in favor of Bay Colony allies when jurisdiction to govern both colonies was granted to a royal governor with authority over his lieutenant who served in New Hampshire. However, the tide began to turn once more when John Wentworth, a native of Portsmouth, was appointed as lieutenant governor of New Hampshire in 1717, beginning a dynasty of royal appointments that included two more generations of Wentworths. By skillfully courting the favor of the Crown and wealthy merchants within the province, John Wentworth expanded his family's influence and further frustrated ambitions of the Bay Colony to assert control over New Hampshire.

The disputed boundary between the two colonies finally emerged as a major political battleground in the 1720's. John Wentworth died in 1730 before seeing the issue settled, but an agent that he enlisted to plead the case before authorities in London, Captain John Thomlinson, ultimately prevailed. In March of 1740, a measure advantageous to New Hampshire was passed setting the southern boundary along a line due west from the southerly curve of the Merrimack River at Lowell, Massachusetts. Thomlinson achieved a final coup in 1741 by successfully

lobbying King George II to appoint Benning Wentworth, John Wentworth's son, as royal governor of New Hampshire, separate from and independent of Massachusetts.

The political power struggle between these two New England colonies was not the only source of conflict in the region during the early period of settlement. New Hampshire occupied the frontier between British and French territorial claims in North America which insured that it would be a battleground in the protracted struggle for domination. A succession of wars between the English settlers and the French and their Indian allies began as early as 1675 and lasted almost one hundred years, with depredations on both sides. Dover was raided by several hundred Abenaki and Pennacook Indians in June 1689 under the command of chiefs Kancamagus and Mesandowit. More than 20 settlers were killed and 29 more taken captive and marched to New France to be sold or held as hostages.

Numerous chilling accounts of such attacks and heroic defenses exist from this period, creating their own literary genre, the "captivity narrative." The story of Hannah Dustin (a.k.a. Hannah Duston), who was captured in Haverhill, Massachusetts along with her newborn daughter and her nurse during a raid in 1697, is especially compelling. On the way north, the Indians murdered the baby and several other captives. Hannah Dustin, with the aid of the nurse and a teenage boy, were able to overpower their captors while they camped on an island in the Merrimack River, killing two adult men, two adult women and six children before scalping them and escaping downriver in a canoe.

Source: http://en.wikipedia.org/wiki/File:Hannah_Duston,_by_Stearns.jpg

The site in Boscawen, New Hampshire is commemorated by a statue of Hannah Dustin wielding a hatchet, which was erected in 1874, the first publicly funded statue in New Hampshire.

Settlement continued, despite the dangers. The vast timber resources of the virgin forests provided an irresistible economic incentive. By the 16th century the English homeland had been largely denuded of its own forests and the British navy required a secure and steady supply of exceedingly straight, tall trees, "mast trees", to maintain its maritime superiority. The settlers required lumber for buildings, barrels, and household tools of all descriptions, as well as up to 40 cords of firewood each year for fuel. The old-growth forests, with their giant white pine trees up to 230 feet tall, met both requirements.

The first pine masts were shipped out of the Piscataqua region bound for British ports in 1634 and Portsmouth came to dominate the lucrative masting trade until shortly before the American

Revolution. The glaciated landscape of New Hampshire provided abundant opportunities to develop water power and sawmills and grist mills sprang up as a vital part of almost every new settlement. The settlers could turn the surrounding forest into products to meet their own needs, but also soon realized that there was an enormous export market for lumber, clapboards, shingles, and barrel staves throughout the British colonies.

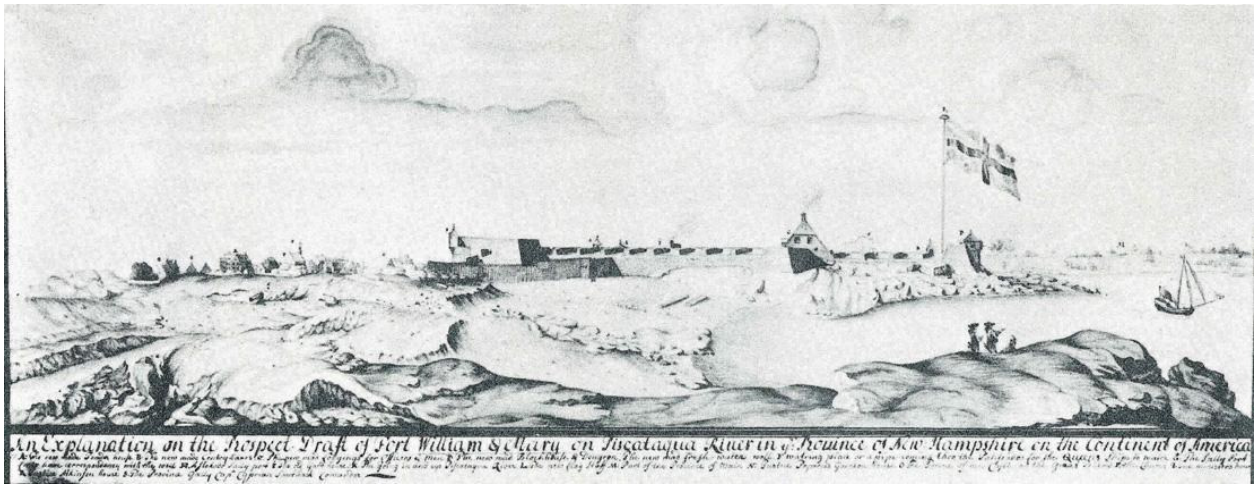
As the easily accessible timber in the Piscataqua region was cut over, competition rapidly increased between the settlers and their merchant middlemen and the powerful colonial agents of the masting trade. Restrictions on the cutting of pine soon followed in 1691, enforceable by Crown-appointed Surveyors of His Majesties Woods and Forests. Pines more than 24 inches in diameter at 12 inches above the ground were branded with the King's Broad Arrow as potential mast trees and property of the Crown. With three quick strokes of an ax, surveyors appropriated the best pines for the Royal Navy. Settlers routinely poached these pines and sawed them into boards that were no more than 22 inches wide to avoid being discovered by the King's agents.

Enforcement of the white pine laws was lax under royal governors John Wentworth and then his son Benning Wentworth. Although they both profited immensely from the masting trade, they also benefited both politically and financially from the success of merchants in the lumber trade. A delicate balance was required to maintain the favor of the Crown as loyal subjects while encouraging the entrepreneurial spirit of the colonists under their direct authority.

Prospects for increased settlement improved after the Treaty of Paris was signed in 1763, ending the French and Indian Wars. Benning Wentworth took full advantage of confusion over the western boundary of New Hampshire and began to charter new towns on both sides of the Connecticut River. Under his skillful leadership, which came to an end in 1767 when he lost favor with the Crown and relinquished the governorship, the colony expanded and became more secure and prosperous. Political maneuvering at the court of King George III resulted in Benning's nephew, John Wentworth II, being named as his successor. Unfortunately, John II lacked the friends in high places that his kinsman had so effectively cultivated in London and could not afford to be so cavalier about enforcing the laws against smuggling and cutting of the King's pines. His heavy-handed approach, however, did not win him friends among the colonists either. What became known as the Pine Tree Riot transpired during April of 1772 in the town of Weare after one of Wentworth's inspectors charged a number of local men with cutting a large number of the King's pines, marked the illegal logs for seizure, and fined all of the offenders. In an act of open defiance, a mob of more than 20 men with faces covered in soot to hide their identities assaulted the government officials the following morning and sent them packing toward the Mast Road and out of town. Unrest in the colony would only increase and lead to the opening volleys of the American Revolution.

While the midnight ride of Paul Revere in April 1775 has achieved mythical proportions, dramatic events that occurred in New Hampshire during the previous December have received

much less public notice. Paul Revere served as a courier from Boston to Portsmouth to deliver an urgent message that the British had banned export of military stores to America. More alarmingly, he reported that troops were already en route to occupy Castle William and Mary on Newcastle Island in Portsmouth harbor, intent on securing all its arms and ammunition. The British were coming. A preemptive strike was organized, and on December 14 four hundred patriots under the command of Captain Thomas Pickering and Major John Langdon overwhelmed the five British defenders and liberated all of the gunpowder that they then distributed in nearby communities for safekeeping. The following night they came back for more, this time hauling away cannons, muskets, and other military hardware.

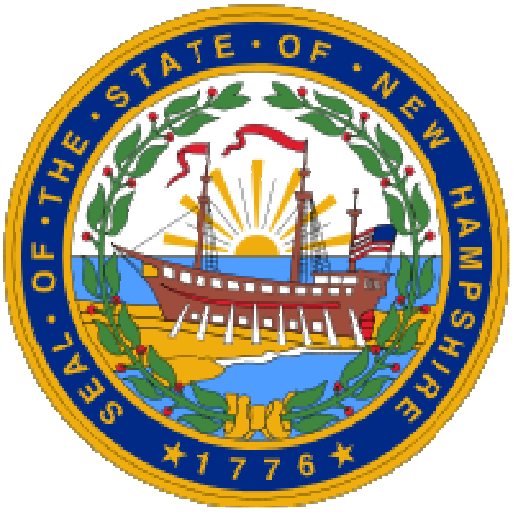


Source: http://en.wikipedia.org/wiki/File:Fort_William_and_Mary,_1705.jpg

The entire affair was a significant embarrassment for Governor Wentworth who was residing in Portsmouth at the time. An angry mob showed up on his doorstep in June 1775 to confront a friend of the governor, Colonel John Fenton, who was staying there. They brought a cannon with them and positioned it in front of the door, threatening to open fire if Colonel Fenton was not handed over. Realizing that resistance was futile, Fenton surrendered. Wentworth got the message and made arrangements to retire his family to the safety of Castle William and Mary, now guarded by two British warships, thence to Boston and finally to Nova Scotia, never to return to New Hampshire. So ended the royal Wentworth dynasty and began New Hampshire's struggle for independence from the Crown.

In January 1776, New Hampshire's became the first colony to write its own constitution and formalize its independence. In Philadelphia on July 4, 1776, New Hampshire delegates were accorded the honor of being the first to vote for the Declaration of Independence. No battles of the American Revolution were fought on New Hampshire soil, but the state contributed three regiments to the Continental Army. Native son and renowned Indian fighter, General John Stark, came out of retirement in July 1777 to lead New Hampshire troops to victory at the Battle of Bennington in southwestern Vermont. As a result of his victory, he decisively blocked the strategic offensive of British General Burgoyne who was attempting to cut off New England from the other colonies. Stark was remembered as rallying his troops on the battlefield by declaring with much bravado, "There, my boys, are your enemies, the red-coats and Tories; they

are ours or this night Molly Stark sleeps a widow." The famous declaration "Live Free or Die", which is attributed to Stark and became New Hampshire's state motto in 1945, was actually never spoken by him during the conflict. Rather he penned the words as part of a toast he sent to his former soldiers in 1809 upon declining their invitation to participate in a reunion thirty-two years after the Battle of Bennington.

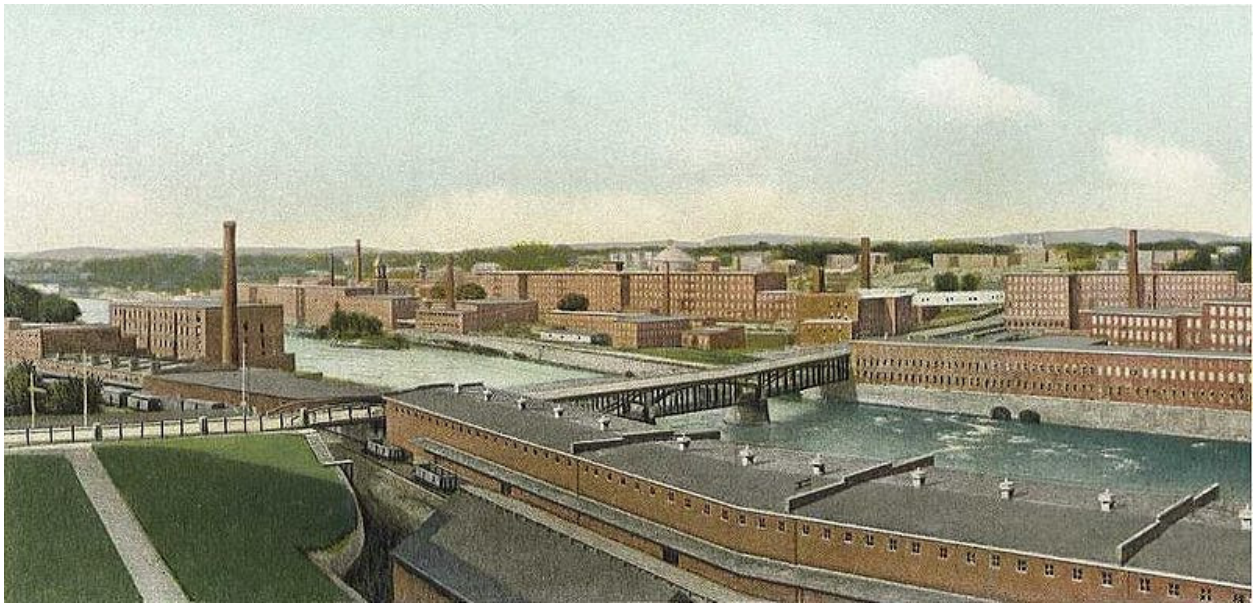


Portsmouth's long experience with seafaring and shipbuilding proved to be a major asset in the war effort. Skilled shipwrights produced numerous vessels for the Continental Navy but also for an intrepid navy of privateers bankrolled by local merchants and venture capitalists. After the war, tribute to this shipbuilding heritage was bestowed by the official seal of New Hampshire that depicts the 32-gun frigate Raleigh while still on the shipyard stocks in Portsmouth. (Major elements of the original seal, created in 1775 by the First Provincial Congress, included a pine tree and an upright fish, acknowledging the natural resources that supported New Hampshire's economy during the previous century). American naval hero John Paul Jones supervised the Raleigh's construction, along with that of another man-of-war, the 18-gun Ranger, which he later commanded. One of these two ships was the first to fly the Stars and Stripes after it was adopted as national ensign by an act of Congress in June 1777. On June 21, 1788, New Hampshire became the ninth state to ratify the Constitution of the United States, providing the final vote needed for it to become the law of the land. Delegates acted deliberately to achieve that distinction, beating Virginia. [New Hampshire's tenacious hold on its First in the Nation Primary status would appear to have deep historical roots.]

The 1817 edition of Merrill's "The Gazetteer of the State of New Hampshire" observed that: "Within the last twenty years, the roads of this state have been much improved, so that communication between the distant parts of it is much facilitated. Much however remains to be done, especially in the northern part of the state…. From the best information I can obtain, we have now open for travel 300 miles of turnpike road, and 300 more will soon be opened." (Page 12). A new era of economic development was beginning as the transportation network expanded. The corridors for settlement and the main arteries for trade and commerce were no longer defined by the major rivers. Those yeoman farmers who settled in the relative isolation of the uplands began to have access to more distant markets and they became a market for goods produced beyond their local communities. When the first railroad line was completed from Lowell, Massachusetts to Manchester, New Hampshire in 1836, the pace of economic change rapidly accelerated.

Manufacturing began on a scale that dwarfed that of the early sawmills and grist mills. Cotton and woolen mills and shoe factories attracted growing numbers of workers from the family farms or newly arrived immigrants to satisfy demand for products in far-flung markets. Two years after the railroad reached Manchester, construction of the Amoskeag Manufacturing Company

began. The world famous gingham cloth and cotton ticking that flooded from the looms of Amoskeag gave Manchester its identity for almost a century. By the middle of the 19th century, the Amoskeag Manufacturing Company was the largest producer of cotton textiles in the world. In its heyday at the turn of the 20th century, the manufacturing complex included thirty major mills covering a total of 8,000,000 square feet of floor space and employed up to 17,000 workers.



Source: http://linguistlist.org/fund-drive/2011/hometowns/danielle/history.cfm

Writing in 1817, Eliphalet Merrill clearly understood the importance of transportation infrastructure as the precondition for development, but he likely never could have imagined the impact that the railroads would have on New Hampshire. The initial 35 miles of track grew to 92 miles in 1845, then 467 miles in 1850 and 661 miles in 1860. During that period Franklin Pierce, "the young hickory of the Granite Hills", was elected as the fourteenth president of the United States, the only New Hampshirite to hold that office. Another 239 miles of track were laid during the 1860's bringing the total mileage to 900 in 1870. During the Civil War years, railroad technology advanced significantly while New Hampshire mustered 18 regiments of volunteers in answer to the call for troops to preserve the Union. Of these, the Fifth Regiment is widely recognized for its hard fighting and number of battlefield casualties in all the major engagements of the Army of the Potomac.

By 1870, the year after State Geologist Charles H. Hitchcock began the Second Geological Survey of New Hampshire, the railroads had united the previously separated regions of the state, including the North Country. The story continues where the tracks ended, in the White Mountains.

White Mountain History

By Frederick Chormann

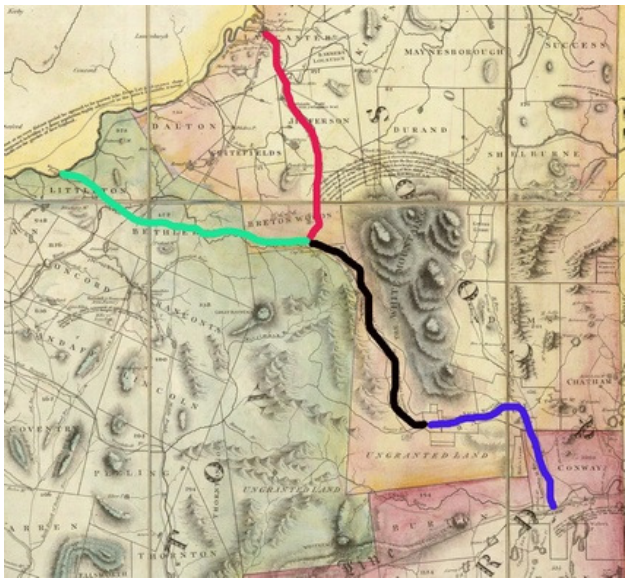
The White Mountains of New Hampshire have long held the fascination of residents and visitors alike. The earliest explorers off the coast of New England reported seeing these high mountains in the distance rising above the seemingly endless green of the virgin forests. Because this region of the state was so rugged, remote, and difficult to access, early explorers and settlers remained on the periphery and relatively few were bold enough to venture into the imposing notches.

The "discovery" of Crawford Notch by Europeans in 1771 or 1773 (depending on sources) is attributed to two hunters, Timothy Nash and Benjamin Sawyer. Governor John Wentworth II, upon learning of this discovery, is said to have offered Nash a grant of land if he could bring a horse through from Lancaster and prove that the route had potential to open up trade with the upper Connecticut Valley. The existence of Nash and Sawyer Location on maps today attests to their success in meeting the governor's challenge.

Rev. Guy Roberts in his booklet "The Willey Slide: Its History, Legend and Romance" (1925) describes the first "rude road" through the notch that was built with funds that were supposedly obtained from the sale of a confiscated Tory estate: *"In places it was so steep that horses and wagons had to be drawn up or let down with ropes. 'Sawyers Rock' being one such place. The first merchandise to go over the road after its completion was a barrel of tobacco taken down from Lancaster to Portsmouth by one Titus Brown. This was followed by a barrel of rum going in the opposite direction, it being a gift from a Portland firm to any one who would get it thru the*

Notch. Captain Rosebrook accomplished the feat, tho most of it was consumed en-route by 'those who helped to manage the affair'."

Publications such as this and the many that preceded it during the 19th century did much to popularize the region and attract and charm tourists, although the historical accuracy of events as reported may have suffered in the service of literary license. However, we do know with certainty that Abel Crawford was one of the first settlers, building a log cabin near the present location of the Fabyan Station Restaurant sometime around 1792. Shortly thereafter, he moved 12 miles down the Saco valley to the vicinity of Notchland and sold his log cabin at Fabyan to his father-in-law, Eleazer Rosebrook. Both locations became natural stops for teamsters hauling freight and other travelers along the road, so that Crawford and Rosebrook eventually found themselves in the hospitality business, providing food, spirits, and lodging to an increasing number of wayfarers. Their once humble accommodations become worthy of being called taverns, a pattern of development that repeated itself all over the White Mountain region in later years as trade, but especially tourism, increased.



The early notch road was succeeded by the 10th New Hampshire Turnpike, which was chartered by the New Hampshire Legislature in December 1803. [The route of the field trip traces the original 20 miles of turnpike from near Sawyer's Rock to the intersection of the Cog Railway Base Station Road with US Route 302. Cherry Mountain Road, which also intersects US Route 302 and is only open for seasonal use, could be the longest, mostly original section of a 19th century turnpike still in existence]. Construction of this and other early turnpikes was paid for by investors because the state did not have the means to fund such enterprises. Shareholders hoped to recoup their investments by charging tolls and furthering their business interests in the area.

Source: http://whitemountainhistory.org/Tenth_New_Hampshire.html

Despite Governor Wentworth's expectation of forging an efficient transportation link to Portsmouth, the 10th Turnpike proved to be a better stimulus for trade with Portland, Maine. Not surprisingly, as local tavern owners and innkeepers, Rosebrook, Abel Crawford, and Abel's son, Ethan Allen Crawford, were major proponents of this and related road building projects during the first decades of the 19th century. Not only were they stockholders, but they also assumed roles as directors, builders, and toll collectors. Abel and Ethan Allen Crawford are remembered as well for clearing a path to the treeline near the top of Mt. Clinton in 1819. The completed trail, known as the Crawford path, extends a total of 8.2 miles over the southern Presidential Range to the summit of Mt. Washington from Crawford Notch and is the oldest maintained foottrail in the United States. The Crawfords improved the trail as a bridle path in 1840. Charles

T. Jackson, first State Geologist of New Hampshire, made the first ascent on horseback that year with Abel Crawford as his guide. Jackson made the following observations:

"*The geological features of Mount Washington possess but little interest, the rocks in place consisting of a coarse variety of mica slate, passing into gneiss, which contains crystals of black tourmaline and quartz. The cone of the mountain and its summit are covered by myriads of angular and flat blocks and slabs of mica slate, piled in confusion one upon the other. They are identical in nature with the rocks in place, and bear no marks of transportation or abrasion by the action of water*." (Page 78) [Note: Jackson was an ardent believer in diluvialist theories and dismissive of any notion of widespread glaciation.]

Jackson did concede, however, that "the geologist will be fully rewarded for his toil in ascending this mountain, by the magnificent and comprehensive view which may be obtained of the surrounding country." Eminent British geologist Sir Charles Lyell and his wife made the trip in October 1845, in the company of an accomplished botanist from Boston, a gentleman and his wife visiting from Maine, a young New England artist, and three guides. The different interests of the various participants exemplify how appealing a visit to the White Mountains had become.

Road construction over the steep and rocky terrain of the Crawford Notch was challenging enough but maintenance of the road was equally if not more challenging. The rainstorm in August of 1826 that was responsible for the tragedy of the Willey family [Stop 6] washed out parts of the road and buried others under many tons of debris. The damage that occurred to the roadbed and bridges probably has a good analogue in the havoc wreaked in the same general area by Tropical Storm Irene in August 2011. [Bridges damaged by Tropical Storm Irene are located at the second and third drive-by sites.] The tragedy was sensationalized in the newspapers of the day and ironically became a boon to tourism as people were drawn to the scene of the disaster. To add to the sense of pathos and moral ambiguity of the event, chroniclers likely embellished the tale with details of questionable veracity, such as providing the image of a burnt out stub of a candle on a table beside the family bible in a hastily abandoned room, the bible open to the 18th Psalm which begins "The Lord also thundered in the heavens". The road was re-opened and by 1830 could be readily negotiated by stagecoaches, the preferred method of mass transit at the time. The Abbott Downing Company in Concord, New Hampshire manufactured some of the most widely used passenger models (the premier "Concord coach") on the road. Travel to Fabyan and other White Mountain destinations took less time and became at least less arduous if not more comfortable.

The approach of the first railroad lines ushered in a new era of comfort and convenience for the traveler. One could leave Boston or Portland in the morning and dine in the White Mountains that evening, perhaps even having time to take in a few of the sights before dinner. Stagecoach lines still provided links to the nearest rail depots. Sir Charles Lyell, shared his personal perspective on traveling by rail in 1845:

"*It is an agreeable novelty to a naturalist to combine the speed of a railway and the luxury of good inns with the sight of the native forest – the advantages of civilization with the beauty of unreclaimed nature – no hedges, few plowed fields, the wild plants, trees, birds, and animals*

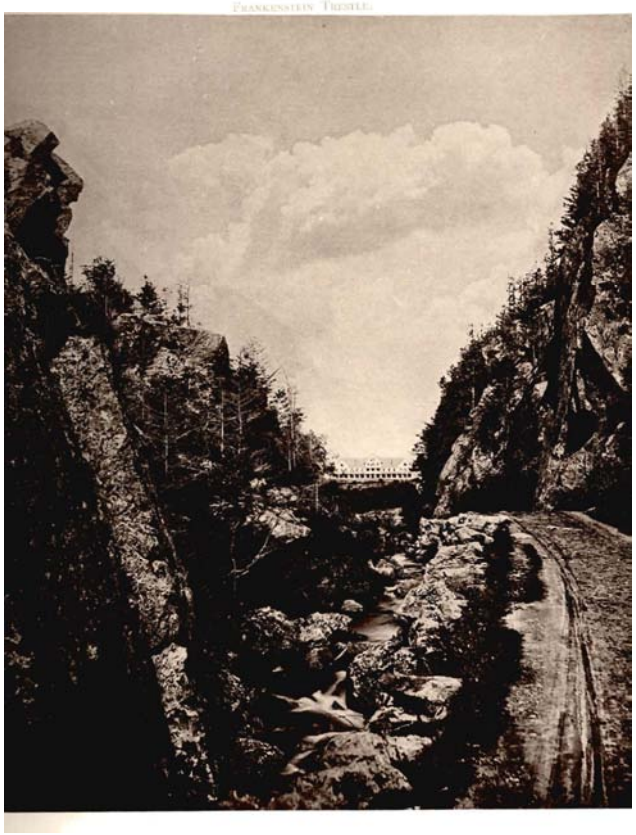
undisturbed." (A second visit to the United States of North America, vol. 1, New York: Harper and Brothers, 1850, page 41.)

The popularity of the White Mountains as a travel destination grew steadily as more and more visitors came and shared their experiences. Praises were sung in the popular media of the day, tour guidebooks of all kinds abounded, inns and taverns aggressively promoted themselves, and artists gave expression to the majestic and picturesque landscapes that they encountered. A tour of the White Mountains, encompassing many of the remarkable geologic features and views that were widely publicized, soon became fashionable for those with financial means and leisure time. Sights such as the Old Man of the Mountain [Stop 3], the Flume, and the Basin in Franconia Notch were high on the list of what to see. In his popular book "The White Hills: Their Legends, Landscape and Poetry" published in 1859, Thomas Starr King appealed to visitors to stay in one location long enough to appreciate the effects that different qualities of atmosphere and light had on the scenery, rather than rushing from place to place heeding the itineraries promoted by the guidebooks. [Today's equivalent practice might be "bagging peaks", the attempt to climb all 48 of the peaks that exceed 4,000 feet in elevation]. King advocated returning to the same places in all seasons, even winter.

The many landscape painters who came to the Whites created a body of work (loosely referred to as the "White Mountain School") that essentially reflected King's aesthetic, although works depicting winter scenes are relatively rare. Painting flourished during the latter half of the century as some artists established studios or became artists-in-residence at the various hotels. [Two different exhibits of White Mountain art are currently open and highly recommended: "Passing Through: The Allure of the White Mountains" at the Museum of the White Mountains in Plymouth, NH (http://www.plymouth.edu/museum-of-the-white-mountains/exhibitions/) and "Mountain Scenery" at the New Hampshire Historical Society's museum in Concord, NH (http://www.nhhistory.org/museum.html).]

In 1851, rail service reached Gorham, at the gateway to Pinkham Notch, via the Atlantic & St. Lawrence Railroad that connected Portland, Maine in the east to Island Pond, Vermont in the west. Construction of The White Mountain Station House (later better known as the Alpine House) was completed that year, providing plenty of accommodations for passengers. A stage road to the future site of the Glen House at the base of Mt. Washington had already been completed the previous year. It was far from coincidental that the era of the grand hotels coincided with development of rail lines into the interior of the White Mountains. The tourist economy literally picked up steam as rail service arrived from different directions throughout the next quarter century, bringing an impressive number of visitors to the region.

A carriage road to the summit of Mt. Washington was completed in 1861, providing even easier access to the ultimate destination of many tourists than was offered by the already existing bridle paths. Attention shifted to the west side of the mountain once the Cog Railway (picture on previous page) was completed in 1869, an ambitious project that was the vision of Sylvester Marsh. Marsh received a legislative charter for the Mount Washington Railway Company in 1858 but didn't break ground for the project until 1866. The novelty and efficiency of this marvel of engineering proved to be as much a tourist attraction as the mountain itself.



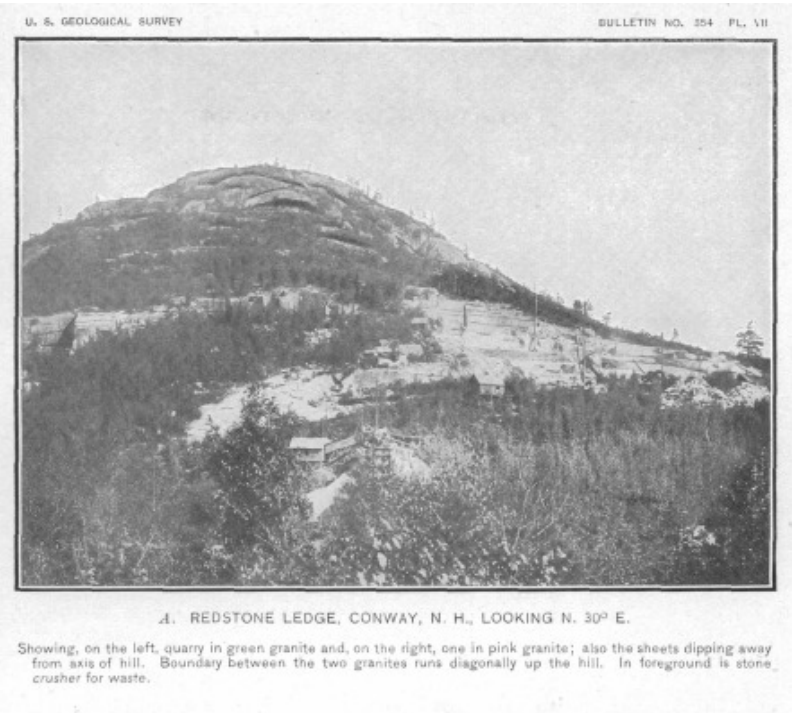
The Portland & Ogdensburg Railroad (P&O RR) built one of the last lines into the interior of the Whites, confronting the considerable engineering challenges posed by Crawford Notch. Having reached Conway in 1871, track was extended to Bartlett in 1873 [the route followed by the Conway Scenic Railroad dinner train] and then on to Notchland one year later. Because of the steepness of the grade and the narrowness of the notch beyond Notchland, track was laid on a shelf that was blasted and excavated out of the sides of Mounts Bemis, Willey, and Willard to reach the "gate of the notch." Trestles were constructed to carry the tracks over gorges and ravines in the mountainsides. Frankenstein Trestle was named after an artist who frequented Notchland and not Shelley's monster.

The first train to reach Fabyan from Portland arrived on August 7, 1875, essentially completing the passenger rail network in the region. As momentous as this occasion might have been, an event that occurred eight years earlier in Concord would have far more extreme and lasting consequences. In 1867, the administration of Governor Walter Harriman authorized the sale of the state's extensive land holdings in the White Mountains (172,000 acres) to local landowners and speculators. The sale generated an estimated $25,000 in revenue deposited in a "literary fund" to support the financing and maintenance of schools. [Ironically, school funding remains a hotly contested issue in the state today.] A virtual

land grab ensued, with large parcels of virgin forest being acquired by timber interests. The railroads too realized the opportunity to get a piece of the action, having by this time already amassed immense wealth and political and economic influence in the state. The miles of "mountainous forest" that Charles H. Hitchcock had experienced during the Second Geological Survey now came under the lumberman's axe and saw on an industrial scale.

To access all of those trees, timber barons such as James E. Henry of Lincoln contracted with the railroad companies to lease the equipment needed to build and operate their own network of logging railroads throughout the Whites. Seventeen spur lines emerged to carry the logs from the woods to the mills and then deliver timber products to market. Regrettably, the science of forestry was in its infancy at this time. Whole mountainsides were completely clear-cut in one area and then the operation pulled up stakes (and tracks) and moved on to the next. Vast tracts were left with nothing but slash everywhere, just waiting for a spark or lightning strike to set them aflame.

As this environmental catastrophe was unfolding, guests at the many grand hotels began to complain that their much-loved views were becoming blighted. Some days there were no views at all because smoke from fires obscured everything and soot and ashes rained down on the spacious hotel verandas, keeping guests indoors. In 1903 alone, over 12,000 acres burned. Needless to say, all of this was very bad for the businesses that depended on tourism. A public outcry against the logging abuses gained strength, joining the voices of hotel owners, conservationists, and even large mill owners beyond the region. The latter group recognized a threat to the sustained flow of water in the rivers that generated power for their machinery. The Society for the Protection of New Hampshire Forests was founded in 1901 to advocate for better forestry practices and land protection. Action finally came in the form of the Weeks Act that was passed by the U.S Congress in 1911 and was named for the senator who sponsored the legislation, John Wingate Weeks. The precedent setting argument was successfully made that the federal government had the right to purchase and own private property for the purpose of protecting the headwaters of navigable streams. This was the impetus for the creation of the national forest system. The White Mountain National Forest was officially recognized in 1918.



A. REDSTONE LEDGE, CONWAY, N. H., LOOKING N. 30° E.

Showing, on the left, quarry in green granite and, on the right, one in pink granite; also the sheets dipping away from axis of hill. Boundary between the two granites runs diagonally up the hill. In foreground is stone crusher for waste.

Timber was not the only resource of interest in the Whites. When the P&O RR reached Conway in 1871, it laid track at the base of Rattlesnake Mountain and made use of the large granite boulders

found there, which could be easily split to provide dimension stone for the railroad. The quality of the Conway Granite was soon recognized and the Redstone Quarry opened in 1886. Much of the product was shipped elsewhere for use as paving stones, but the railroad itself had an enormous need for granite blocks for constructing abutments and also for architectural use in building many of the grand stations along its lines. However, the market for Redstone products was more extensive than this. Grant's Tomb in New York, the National Archives building in Washington, and the George Washington Memorial Masonic Temple in Alexandria, VA were built mostly of Conway pink granite. [A 3,000-foot borehole was drilled in 1975 at the site of the quarry in an effort to assess the heat flow and geothermal energy potential of the Conway Granite. This remains the deepest hole ever drilled in the state].

In the early 1900's, the automobile began to displace the railroads as the preferred method of travel and the railroads and grand hotels went into slow decline. Tourism continued to thrive even as these venerable institutions faded from the scene. The first steam-powered automobile climbed to the summit of Mt. Washington in 1899 on what was to become the Mt. Washington Auto Road. The first gasoline-powered car "summited" in 1902. [Today, car bumpers bearing "This Car Climbed Mt. Washington" stickers are a common sight. Events sponsoring contests of various forms of human-powered locomotion are also a regular occurrence on the Auto Road]. Echoing the turnpike statistics cited by Eliphalet Merrill one hundred years earlier, the State Highway Department reported in 1919 that:

"*The system of trunk line highways alone comprises 1,300 miles of which 909 have been already built and 391 are about to be built. Most of New Hampshire's roads are gravel and no better riding surface has been designed than a substantial, smooth gravel road. There are large deposits of gravel in the state that have been made available for this purpose, which fulfill all the requirements and have the advantage of being the cheapest road material under the conditions*." (New Hampshire: A pamphlet concerning the activities of certain of the State Departments, Concord, September 15, 1919, p. 22)

The Civilian Conservation Corps (CCC), with camps throughout the White Mountains, added to this network during the 1930's. Tripoli Road was built from North Woodstock to Waterville Valley and an 8-mile segment of US Route 3 in Pittsburg that reached the Quebec border, creating the state's first and only port of entry to Canada in 1940. Work crews from Camp Peabody worked to clear blow-downs from the Mount Washington Auto Road after the Hurricane of 1938. Altogether, CCC enrollees built 277 miles

of new roads and truck trails across the state. At that time, no improved road existed between the former logging camp site at Passaconaway on the Swift River and the village of Lincoln on the East Branch of the Pemigewasset River. The gap was closed in the 1950's with the construction of the Kancamagus Highway. The Franconia Notch Parkway became part of the interstate highway system [I-93] in 1988 and is the only stretch of interstate in the country constructed without a median strip.

The forests of the White Mountains have regenerated and geologists have found plenty to interest them in the time since Charles T. Jackson looked at the rocks on the top of Mt. Washington and yawned. Scientists still inhabit these storied mountains as the Mt. Washington Observatory continues the legacy of discovery that State Geologist Charles H. Hitchcock began during the winter of in 1870-71 when he maintained a meteorological station on the summit, the first high-mountain observatory in the United States.

New Hampshire Geologic History

By Frederick Chormann and Wally Bothener

Notes: The recently published book, "The Geology of New Hampshire's White Mountains" (Durand Press, 2013) is highly recommended as an excellent source of additional information.

Specific rock units that are traversed by the route of the field trip are printed in bold where first introduced in the narrative below.

The role of plate tectonic theory in enabling geologists to piece together the geologic history of New Hampshire cannot be overestimated. The entire rock record, as documented by scores of geologists over the past 175 years, can be understood in the context of a model of crustal evolution whereby new plates and crust are created by extension at divergent boundaries while other plates are being enlarged by accretion and/or consumed by subduction at convergent boundaries. Ocean basins open and accumulate sediment eroded from continental highlands and deposited by volcanic activity associated with island arcs and continental plate margins. Basins close as plates collide, culminating in a new episode of mountain building. Deformation and metamorphism are pervasive during orogenesis, accompanied by partial melting of crust and extensive formation of granites together with intense volcanic and seismic activity. Plates coalesce by accretion only to be split apart to form new configurations as rifting is renewed in response to dynamic changes in the driving forces. Tectonic lithofacies mapping provides the key to plate reconstruction.

The bedrock of New Hampshire is the product of a succession of tectonic events that occurred along the continental margin of the Laurentian plate beginning with the Taconic orogeny in middle Ordovician time. Collision and accretion added to the continental mass, processes that were repeated during the Siliurian Salinic and mid-Devonian Acadian orogenies, deforming the older rocks and producing new ones. The culminating Permian Alleghanian Orogeny created the supercontinent Pangea, a "backbone" of which is the Appalachian Mountain chain. The northern portion of that chain includes the White Mountains of New Hampshire. Early Mesozoic rifting associated with the breakup of the Pangean supercontinent is evidenced by the presence of north to northeast trending normal faults and basalt dikes and the intrusion of large composite igneous bodies, ring dikes, and associated explosive volcanic rocks.

The lithotectonic associations of the oldest rocks in New Hampshire remain uncertain despite considerable study. The Massabesic Gneiss Complex of migmatitic gneisses is Late Proterozoic in age. The main body of Massabesic trends northeasterly across southeastern New Hampshire, aligned with the pronounced regional structural grain and bounded by the Silurian Berwick Formation of the Merrimack belt to the southeast and rocks of the Central Maine terrane to the northwest. Dorais et al. (2012) now characterize the Massabesic as an inlier of the Gander terrane which is more prominently exposed farther northeast in the Maritimes of Canada where it was first recognized. Earlier interpretations include the Massabesic as part of the more outboard Avalon terrane of southeastern Massachusetts and Rhode Island.

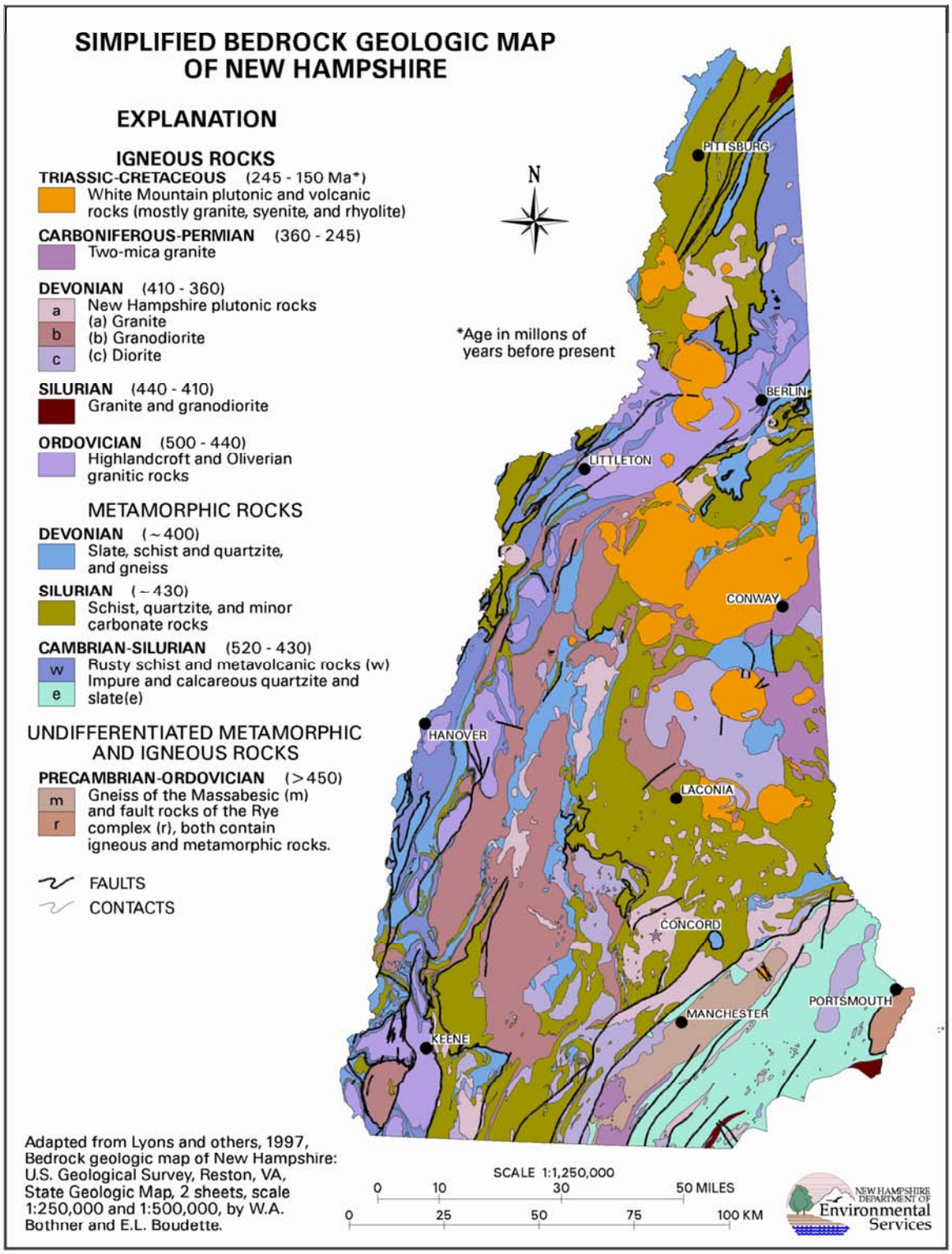


Figure 1 – *Simplified Bedrock Geologic Map of New Hampshire*

Gander and Avalon originated as several elongated segments that rifted from the Gondwanan plate when it was on the far side of the Iapetus Ocean from the Laurentian plate. The geologic history of New Hampshire during the Paleozoic is defined by the ultimate closing of this basin, bringing segments of the Gondwanan plate (Gander, then Avalon, finally Meguma), sediments from their intervening ocean basins and a succession of volcanic island arcs associated with subduction zones into contact with the evolving Laurentian plate margin. All of these events are believed to have occurred while the plates where located near the equator.

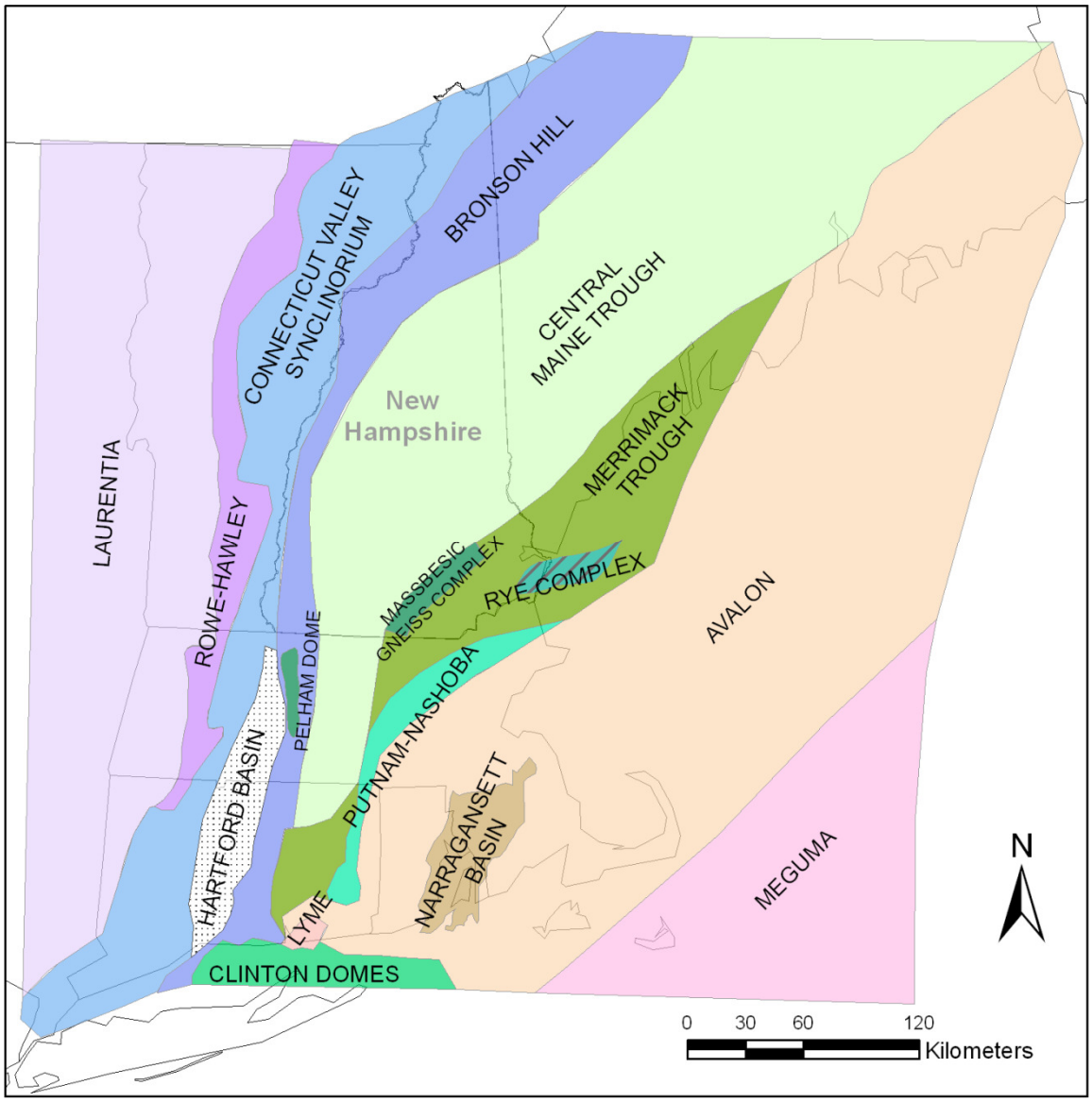


Figure 2 - *Generalized map of lithotectonic terranes in New England; modified from Figure 1 of Dorais, et al. 2012. Note: Plutonic bodies within the Merrimack Trough are not shown.*

Laurentia grew by accretion during the Ordovician with first the collision of the Shelburne Falls volcanic arc, marking the beginning of the Taconic Orogeny about 480 Ma, and then the Bronson Hill arc about 450 Ma. The main mountain building that resulted, the formation of the Taconic Mountains, was to the west of present-day New Hampshire in eastern New York and western Massachusetts and Vermont. In New Hampshire, the Ordovician rocks occupy a belt along the border with Vermont that coincides with the Bronson Hill volcanic arc and includes an assemblage of sediments, volcanics, and igneous intrusions having an affinity with the Gander plate. These rocks represent the oldest rocks in the White Mountains, among which the metamorphosed sedimentary rocks, mostly shales and sandstones, of the Albee Group (correlated with the Dead River formation of Lyons et al. 1997) of Late Cambrian to Early Ordovician age are the very oldest. This characterization derives from recent mapping within the Connecticut River valley between New Hampshire and Vermont in conjunction with compilation of the new statewide bedrock geologic map for Vermont (Ratcliffe et al. 2011). Stratigraphic nomenclature is in the process of being redefined as a result of this more recent work.

The **Ammonoosuc Volcanics (Oam)** unconformably overlie the Albee and record the eruptions of basaltic and rhyolitic material within the Bronson Hill island arc. Rusty weathering metamorphosed black shales of the Partridge formation lie conformably above the Ammonoosuc Volcanics. This sequence of Ordovician metavolcanics and metasedimentary rocks is intruded by the Oliverian Domes of the **Oliverian Plutonic Suite (Oo1b)** and the Highlandcroft Plutonic Suite that are interpreted to be the magma chambers for the Bronson Hill island arc volcanoes. These granitoid bodies are exposed as elongated elliptical masses enveloped by the Ammonoosuc Volcanics and trending north to northeast along the structural axis of the Bronson Hill Anticlinorium.

At the conclusion of the last of the Taconic compressional events during the Middle to Upper Ordovician, two ocean basins existed off the margin of the Laurentian plate. The Central Maine basin was proximal to the recently accreted Bronson Hill volcanic arc while the Merrimack basin was farther to the east where it was bounded by the Coastal Maine arc. In latest Ordovician time, both basins began accumulating significant deposits of shale, siltstone, and sandstone eroded from the adjacent landmasses. Deposition ceased in the Merrimack basin at the end of the Middle Silurian, but continued through Early Devonian time in the Central Maine basin.

Rocks of the Merrimack basin include the Kittery Formation and Eliot Formation that today underlie the lowlands in the seacoast region of the state. The Kittery is notable for its preservation of primary sedimentary structures such as graded bedding, cross-bedding, and small-scale channel cut and fill structures. The oldest stratified rocks exposed in this region are the mylonitinized metasedimentary rocks of the Rye Complex (presumably Ordovician or older) that occupy the immediate coastal zone. They are separated from the Kittery and Eliot formations to the northwest by the Portsmouth fault. Because of this contact relationship, the basin where the Rye sediments originally accumulated cannot be readily determined (Hussey et al. 2008).

The source of sediments for the Silurian-age Berwick Formation has been attributed to erosion of the Bronson Hill terrane with deposition occurring in the Central Maine basin. Historically, however, the Berwick Formation has been included within the Merrimack Group and the

Rangeley Formation (Srl and Sru) is identified as the oldest unit of Silurian age (430 Ma) within the Central Maine stratigraphy of New Hampshire. The Rangeley Formation is characterized as variably bedded deepwater deposits (pelitic and psammitic gneiss, schist, and granofels) derived from sediment eroded from the Bronson Hill terrane. Eusden et al. (2013) report the occurrence of olistrostromes within the Rangeley Formation throughout the Presidential Range as evidence for active subduction during the Early Silurian. More quiescent conditions prevailed during deposition of the quartzites of the Perry Mountain Formation (Spm), followed by the rusty-weathering, sulfide-bearing schists of the Smalls Falls Formation (Ssf). The contrast between units records a transition to an euxinic depositional environment as circulation within the closing ocean basin became increasingly restricted. More open circulation was resumed during deposition of the calc-silicates constituting the Madrid Formation (Sm), the youngest sedimentary unit in the Silurian sequence.

Sedimentation in the Central Maine basin continued into the Early Devonian with the deposition of the **Littleton Formation (Dl)** that is believed to have been derived from sources to the east and deposited from east to west. The change in presumptive sediment source has been attributed to the approach of the Avalon plate from the present-day east. The metapelites and metawackes with interlayers of rocks of volcanic origin that constitute the Littleton Formation lie conformably above the older Madrid Formation. Rates of sedimentation and intensity of volcanic activity increased as the collision progressed with subduction of the Avalon plate, initiating the most pronounced mountain-building episode recorded in New Hampshire, the Acadian Orogeny.

The New Hampshire Plutonic Suite of Devonian-age synkinematic and postkinematic granites and granitoids is related to the Acadian Orogeny. The Concord Granite, Spaulding Tonalite, Winnipesaukee Tonalite, **Bethlehem Granondiorite (Db2b)**, and **Kinsman Granodiorite (Dk2x)** are included within this group of widely distributed plutonic bodies. Their origin has been linked to the significant thickening of continental crust inboard of the margin of the composite Laurentian terrane as the continental portion of the Avalon plate was subducted beneath it. The increased crustal thickness drove up temperatures sufficiently to cause the rocks to melt, forming magmas that rose through the overlying crust and crystallized as intrusive bodies. Deformation and metamorphism associated with the Acadian Orogeny strongly overprints pre-existing evidence, making the pre-Acadian geologic history far more challenging to decipher.

During Late Devonian to Early Carboniferous time, a period of crustal instability and magmatism referred to as Neoacadian, less dense rocks of the Oliverian Domes rose upward as remobilized solids, displacing the more dense Ammonoosuc Volcanics and other overlying Silurian metasedimentary formations. The contact relationships create a map pattern where the older gneissic domes appear as “islands” surrounded by younger metasediments, hence the term “mantled gneiss domes.” A number of light gray to white, fine-grained two-mica granites were also emplaced during this same period, cross-cutting all the Acadian metamorphic rocks and the Acadian folds and faults. Named bodies include the Alderbrook, **Bretton Woods**, Bickford and Peabody granites (unit **D1m** of Lyons et al., 1997). The Permian-age Sebago pluton represents the last magmatic episode in the White Mountains during the Paleozoic.

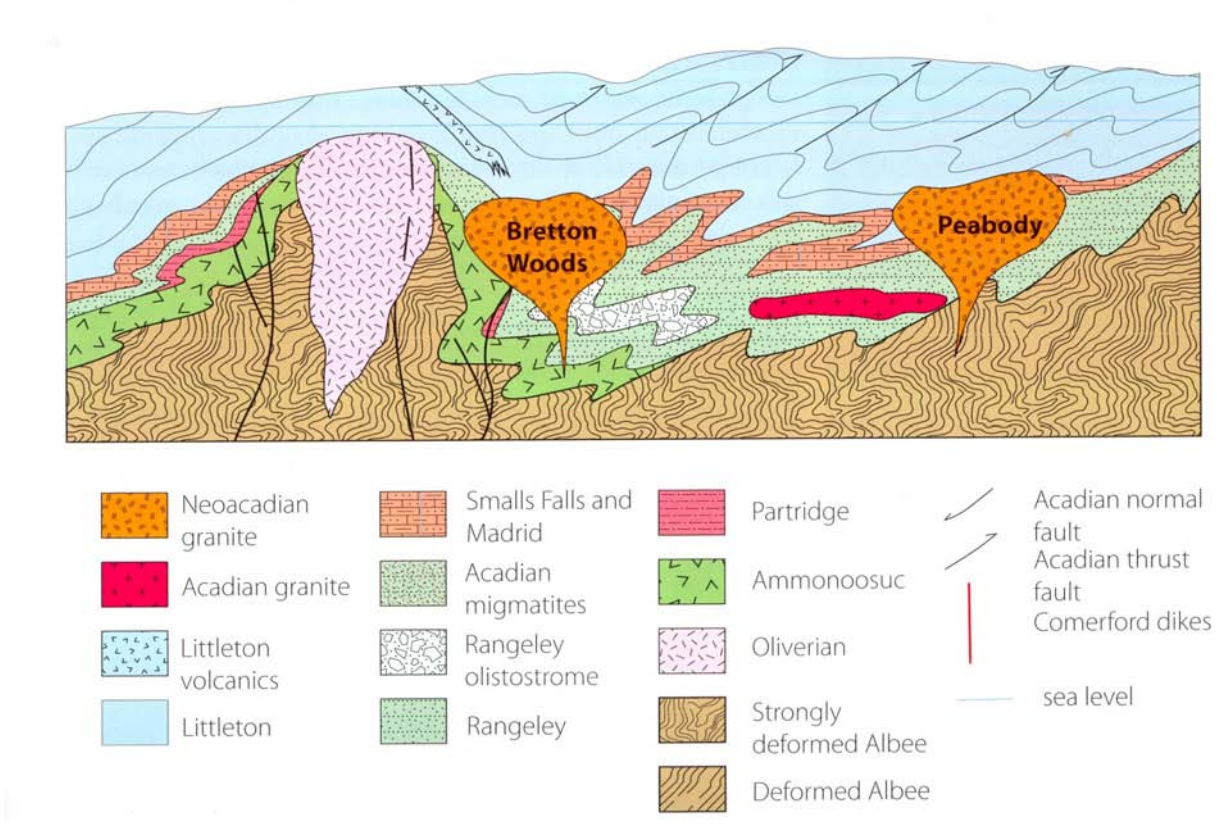


Figure 3 - *The figure above is an idealized cross-section through the complete Late Cambrian to Early Devonian stratigraphy within the White Mountains (Figure reproduced from "The Geology of New Hampshire's White Mountains", Durand Press, 2013, with permission of the authors.)*

By the end of the Paleozoic the composite Laurentian terrane was united with the Gondwanan plate to create the supercontinent Pangea as the Iapetus Ocean finally closed. This configuration was short-lived. Changes in the underlying geodynamic forces initiated large-scale fracturing and rifting during Late Permian through Early Triassic times (240 and 210 million years ago). The new supercontinent began to break up. Extension of the crust resulted in a series of north- to northeast-oriented fault-bounded basins along the margin of the proto-North American plate. The Ammonoosuc fault, located along the eastern boundary of the Connecticut River valley in New Hampshire, has been identified with this episode of Mesozoic rifting. To the south from northern Massachusetts through central Connecticut, the Northfield – Hartford basins preserve huge volumes of Triassic-Jurassic arkosic sandstones and abundant basaltic volcanic rocks that reflect failed continental extension. In addition, swarms of northeast-trending basalt dikes along coastal New England, and more sporadically (forest cover) throughout inland New England, provide further evidence.

Crustal extension has been proposed as a significant factor in explaining the active magmatism that occurred in parts of east-central and northern New Hampshire (as well as elsewhere in New England and Quebec) during the Triassic, Jurassic, and Cretaceous time periods. The rocks associated with this activity in New Hampshire are represented by the White Mountain Plutonic-

Volcanic Suite, mostly identified with Early Jurassic granite plutons. These overlapping centers of magmatic activity stand out boldly on the simplified bedrock geologic map (Figure 1) as golden yellow areas with roughly circular outlines.

Some of these intrusive bodies with their associated arcuate ring dike geometries provide a revealing view into the deep magmatic "plumbing" systems that sustained active volcanism during the Jurassic. They have long attracted the interest of geologists. The ring dike complexes in the Ossipee Mountains and Belknap Mountains near Lake Winnipesaukee are regarded as classic localities and continue to be favorite destinations for geologic field trips. Other notable examples are found in the White Mountain region, including the Pliny Range immediately north of the field trip route and several localities that are even closer. Indeed the entire White Mountains composite batholith can be viewed as a series of overlapping caldera complexes. Some of the most notable are defined by the syenite ring dike opposite the Cannon pluton, at **Lower Falls** on the Swift River near the west side of Moat Mountain, Mt. Tripyramid, Hart Ledge, and Jackson Falls; we drive through most of these on the trip.

The model for the genesis of ring dike complexes invokes an initial doming of overlying rocks in response to the intrusion of a significant volume of magma at a relatively shallow depth. The associated stresses result in the formation of ring-shape fractures that encircle the magma chamber below them and often become outlets for minor eruptions. This stage is a prelude to major explosive eruptions that expel great quantities of hot ash, gases, and volcanic debris and partially empty the magma chamber in the process. The accumulation of volcanic ejecta that blankets the surrounding landscape may be preserved as thick, extensive layers of pyroclasic rocks. Because the volcanic edifice is no longer fully supported, the roof of the magma chamber collapses along the ring fractures to form a steep-sided caldera. The caldera is subsequently filled by the eruption of new ash flows from the ring fractures. The **Moat Volcanics (Jmv)**, underlying the three peaks of the Moat Range and also Big Attitash Mountain to the west of North Conway as well as Kearsarge North and Bartlett Mountain to the northeast, originated in this manner. Lithologies range from fine grained tuffs to coarse breccias. Volcanic activity eventually subsides and ring dikes are formed as magma within the ring fractures cools and solidifies, in this case forming **Albany Porphyritic Quartz Syenite** (unit **J4hx** of Lyons et al., 1997). This distinctive unit has an overall pink to gray appearance with larger crystals of quartz and feldspar more or less uniformly distributed within a fine-grained matrix. The sequence may conclude with the intrusion of new granitic magma into the assemblage of older volcanic rocks, creating discordant contacts between resulting rock units.

The Jurassic-age **Conway Granite (Jc1b)** and **Mt. Osceola Granite (Jo1b)** are widely exposed throughout the White Mountains and were largely derived from resurgent magma sources as described above. The White Mountain Batholith is a composite of the magma bodies from which these two dominant plutonic rocks were formed. The mineralogy of the two granites is distinctly different but distinguishing them in the field can be challenging because each is subject to variations in its composition and appearance. The typical Conway Granite is a medium- to coarse-grained, pink, biotite two-feldspar (pink orthoclase gives it its color) granite, whereas the Mt. Osceola Granite is often greenish (Billings described it as "dirty" green) and contains only one feldspar plus amphibole and pyroxene.

A period of relative inactivity followed the intense magmatism and volcanism that characterized the Jurassic, lasting from 130 to 108 million years ago. One final episode of magmatic activity during the Cretaceous resulted in the intrusion of roughly east-west striking basaltic dike swarms and a few minor plutons of the same age. In the absence of significant geologic events since that time, the inexorable forces of weathering and erosion have outpaced gradual uplift to exhume the geologic record that has been described in this section. The Pleistocene Epoch added a final flourish to the story.

New Hampshire was over-ridden multiple times by continental ice sheets as the climate cooled beginning approximately 2.6 million years ago. Evidence for each episode of glacial advance and retreat was largely erased by the next one. Today we are left mostly with the remnants of deposits that resulted from the last event, the Wisconsinan stage of the Laurentide ice sheet that reached its maximum extent about 20,000 years ago. The ice margin melted back through coastal and southern New Hampshire beginning about 16,000 years ago; the northernmost landscape was virtually ice-free by about 11,000 years ago.

Upland areas were left with a relatively thin covering of glacial till, varying in density from a compact silt- and clay-rich lodgment till to a sandier, and more permeable ablation till. In places, till from the older Illinoian glaciation is preserved underneath the Wisconsinan deposits, but these "two till" exposures are relatively rare. The stony and nutrient-poor nature of the soils that developed from these parent materials made cultivation difficult and relatively unproductive. The extensive network of stonewalls that bound the fields and pastures of the early hill farms, now largely abandoned and reforested, are a testament to the hard labor involved in clearing and working the land.

The numerous large boulders were formidable obstacles, but also a source of curiosity. Attempts to explain their presence eventually led to acceptance of their glacial origins, once it was recognized that many boulders differed from the underlying bedrock and must have been transported significant distances from points north where outcrops of similar rock type could be seen. Perhaps the most famous glacial erratic in New Hampshire is the Madison Boulder which is composed of Conway Granite, resting on Concord Granite.

Many of the lowlands filled with stratified meltwater deposits that created broad, flat intervales that were far more fertile and easier to farm. An extensive stratified-drift aquifer in the Saco River valley supplies the 4 production wells operated by the North Conway Water Precinct, the source of water for the North Conway Grand Hotel. Figure 4 (next page) provides an overview of the extent of these valley-fill deposits in the area of the field trip based on 1:24,000-aquifer mapping completed in the mid-1990's. In the White Mountains, these areas contrast sharply with the narrow, steep-walled "notches" that were scoured through the mountain fronts once they had been over-ridden by the continental ice sheets. The field trip route takes us through Franconia Notch and Crawford Notch, both famous for their dramatic scenery which is a legacy of their geologic history. Stops 3 and Stop 4 will build on the story of the glacial geology of the White Mountains that has been introduced here.

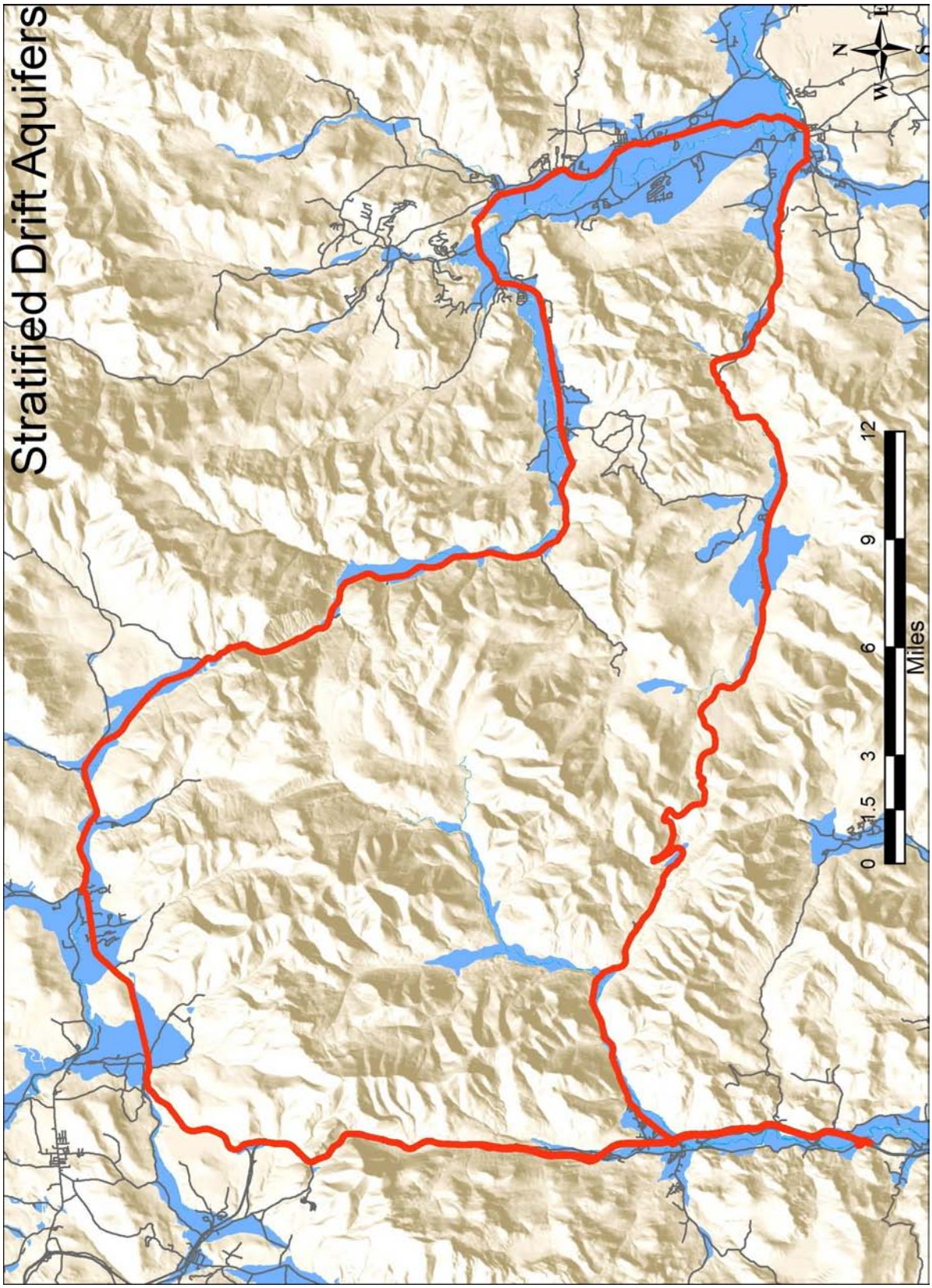


Figure 4 - *Stratified Drift Aquifers in the White Mountain Region*

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